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Department of Physical Geography, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland

Leopold DOLECKI

The Oldest Overtill and Undertill Loesses on the Grzęda Horodelska Plateau (SE Poland)

Nadmorenowe i podmorenowe lessy najstarsze na Grzędzie Horodelskiej (Polska SE)

ABSTRACT

On the basis of studies in exposures and borings the occurrence of loesses and loess-like deposits determined as the oldest loesses (LN) was found. They are separated by till which, from datings by the TL method, were parallelled with Sanian glaciation (=Elsterian II). The occurrence of this till and soils of interglacial rank enabled the distinction of three oldest loesses of different age: LN1 (Liwiec = Fuhne glaciation), LN2 (Sanian = Elsterian II glaciation) and LN3 (Nidanian = Elsterian I glaciation).

In Poland's territory only the western part of the Volhynian Upland is situated, which is characterized by a considerable occurrence of loesses. In this area three subregions are distinguished: the Grzęda Horodelska, Hrubieszów Basin and Grzęda Sokalska. The northern subregion of them, i.e. Grzęda Horodelska is separated from the main part of the Volhynian Upland by the valley of the Bug river, which forms Poland's borderline (Fig. 1).

On the Grzęda Horodelska a continuous loess cover occurs, the thickness of which exceeds in places 38 m, which is here maximal in Poland. Loesses and loess-like deposits of different ages are found here which cover the surface of upper Cretaceous rocks of various relief. In depressions of the

upper Cretaceous surface there occur Eopleistocene sandy-gravel and mud deposits which have not been studied yet in detail and are largely known from descriptions of hydrogeological borings (L. Dolecki 1977, 1981, J. Rzechowski 1987). Mesopleistocene loesses and tills and Neopleistocene loesses studied in numerous exposures and borings occur higher.

In the stratigraphic scheme of loesses in SE Poland were distinguished: younger loesses (LM) from the Vistulian glaciation, older loesses, i.e. Saalian loesses (LS) and oldest loesses (LN) of more than 310–330 ka (H. Maruszczak 1987, 1990). The oldest loesses on the Grzęda Horodelska were distinguished for the first time in the well-known section at Nieledew (H. Maruszczak 1972). In this profile, they occur on sands and gravels with Scandinavian erratic material, covering the upper Cretaceous rocks (J. E. Mojski 1965).

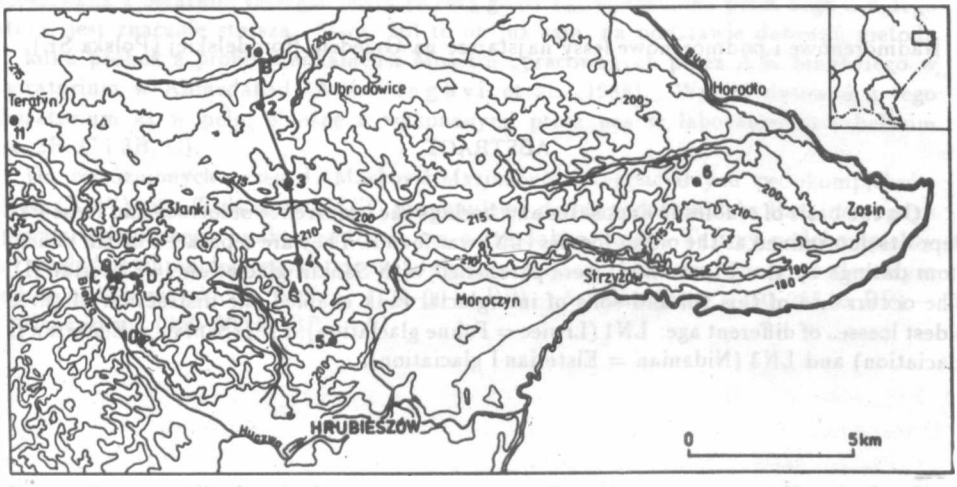

Fig. 1. Location of the discussed borings and exposures on the Grzęda Horodelska
Borings: 1 — Stefankowice; 2 — Stefankowice RSP; 3 — Moniatycze; 4 — Czartowiec; 5 — Hrubieszów CPN; 6 — Kolonia Hrebenne; 7 — Zadębce II; 8 — Zadębce III, Exposures: 9 — Kolonia Zadębce; 10 — Nieledew; 11 — Teratyn. Geological profiles: A — B (Czartowiec — Stefankowice), C — D (Kol. Zadębce — Zadębce III)

In the upper part of LN at Nieledew, interglacial leached brown forest soil has developed. The substrate of this soil was dated by the TL method for 336 ka in the upper part, and for 367 ka in the illuvial horizon (J. Butrym, H. Maruszczak 1983). Below this soil there occur the oldest loesses which in places are underlaid by tills exposed on the surface, dated by the TL method for 445–478 ka, i.e. representing the Sanian glaciation

(= Elsterian II). The borings performed in recent years have revealed that below this tills on the Grzęda Horodelska there occur also loess deposits formed in different facies (L. Dolecki, J. Nowak 1990). Owing to the occurrence of Elsterian till deposits there can be distinguished the oldest overtill loesses, i.e. post-Elsterian and Elsterian undertill ones. The oldest overtill loess was denoted by the symbol LN1 by H. Maruszczak (1990).

THE OLDEST OVERTILL LOESS (LN1)

It has been found in few sections on the Grzęda Horodelska. Besides Nieledew, it occurs at neighbouring Kolonia Zadębce in a similar geomorphological situation (Fig. 1). Here is found till dated by TL method for 445 ka in the upper part of the layer, and for 478 ka in the middle one. Thick gleyed grey-brown podzolic soil of interglacial rank has formed on this till; above it a weakly carbonate loess 1.3 m thick appears which is strongly denudated on a steep slope of the ravine (Fig. 2).

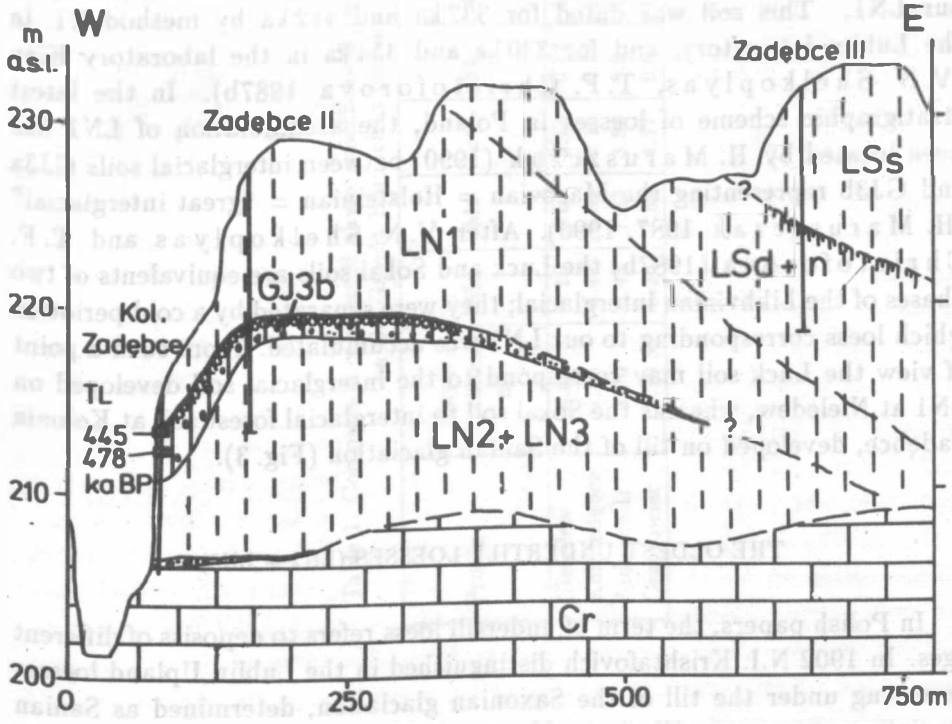

Fig. 2. Geological cross-section Kolonia Zadębce — Zadębce III (explanation as in Fig. 4)

In 1989 two borings were carried out above an section at Kol. Zadębce (Zadębce II and III). In the boring Zadębce II the discussed till was reached at a depth of 8 m. The loesses occurring above it and visible in the section at Kol. Zadębce distinctly resamble LN1 at Nieledew in their characteristic diagnostic features (Table 1). LN1 1.1 m in thickness, strongly transformed by soil-forming processes was also found in the boring K-6 Czartowiec, where it covers the till (L. Dolecki, J. Nowak 1990).

Soil from the Likhvinian interglacial, distinguished by A. Bogucki (1987) as "Luck horizon" was found in the Bojanice profile near Sokal in Volhynia below "the lower horizon of middle Pleistocene loesses" — which are comparable with our older lower and lowest loess. The Luck soil is developed on loesses parallelle with LN1 at Nieledew (H. Maruszczak 1990). Till of Okanian (= Sanian) glaciation, dated by TL method for about 500 ka (V.N. Shelkoplyas, T.F. Christoforova 1987a), occurs below these loesses. On this till forest soil with perfectly formed genetic horizons of total thickness 1.0–1.2 m has developed which is distinguished as "Sokal horizon" (A. Bogucki 1987). In the profile of Volhynian loesses at Korszów, the Luck soil has developed on a deposit corresponding to our LN1. This soil was dated for 332 ka and 412 ka by method TL in the Lublin laboratory, and for 330 ka and 354 ka in the laboratory Kiev (V.N. Shelkoplyas, T.F. Christoforova 1987b). In the latest stratigraphic scheme of loesses in Poland, the accumulation of LN1 has been located by H. Maruszczak (1990) between interglacial soils GJ3a and GJ3b representing the Mazovian = Holsteinian = "great interglacial" (H. Maruszczak 1987, 1990). After V.N. Shelkoplyas and T.F. Christoforova (1987b) the Luck and Sokal soils are equivalents of two phases of the Likhvinian interglacial; they were separated by a cold period in which loess corresponding to our LN1 was accumulated. From such a point of view the Luck soil may correspond to the interglacial soil developed on LN1 at Nieledew, whereas the Sokal soil to interglacial forest soil at Kolonia Zadębce, developed on till of the Sanian glaciation (Fig. 3).

THE OLDEST UNDERTILL LOESSES (LN2 + LN3)

In Polish papers, the term of undertill loess refers to deposits of different ages. In 1902 N.I. Krishtafovich distinguished in the Lublin Upland loesses occurring under the till of the Saxonian glaciation, determined as Sanian glaciation at present. W. Friedberg (1903) distinguished the "drifted" green-grey loam occurring under till of undetermined age in the Carpathian

Table 1. Comparison of selected physico-mechanical and chemical features of oldest overtill loesses LN1 on the Grzęda Horodelska (mean indices for the layers studied)

Profile	Layer thickness m	Md	Mz	σ_I	Sk_I	K_G	Content of loess fraction 0.05-0.02 mm in %%	Content in %%		
								$CaCO_3$	Humus	Fe_2O_3
Nieledew	8.60	6.10	6.68	2.14	0.44	1.02	53.00	0.62	0.13	3.58
Kol.Zadębce	1.30	6.47	6.66	2.15	0.13	0.83	26.60	4.40	0.15	3.11
Zadębce II	8.00	6.45	7.92	3.58	0.62	1.01	39.40	0.68	0.18	2.58
Czartowiec	1.10	6.26	7.84	4.17	0.61	1.03	26.60	0.00	0.14	2.89

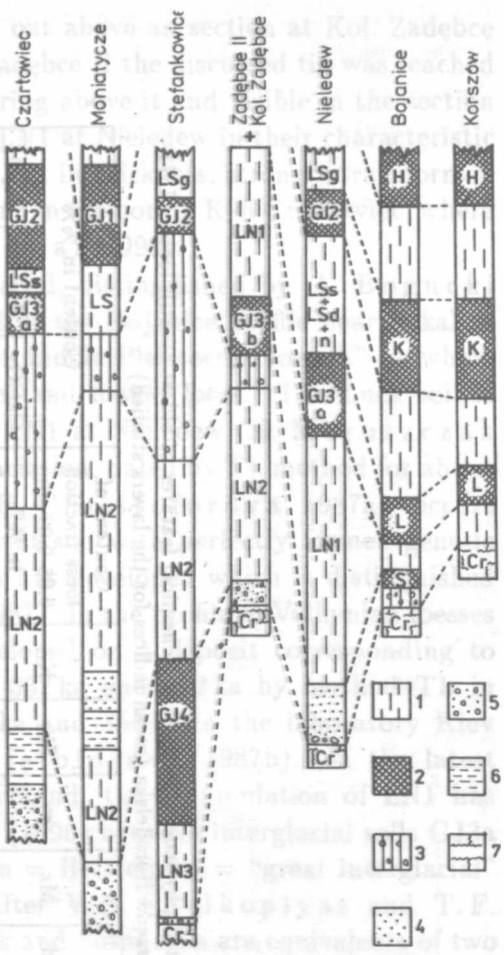

Fig. 3. Stratigraphic parallelization of sections of loesses of the Grzęda Horodelska and western Volhynia (Bojanice and Korszów sections are situated in Ukraine, outside the Polish territory)
1 — loesses and loess-like deposits; 2 — paleosols of interglacial rank; 3 — till; 4 — sands; 5 — sands and gravels without Scandinavian material; 6 — clays; 7 — marls and chalk (Cretaceous). Symbols of stratigraphic units of loesses: LS — older loesses (g — upper, s — middle, d+n — lower and lowest); LN — oldest loesses and loess-like deposits (LN1 — from the Liwiec glaciation; LN2 — from the Sanian glaciation; LN3 — from the Nidanian glaciation). Symbols of interglacial (GJ) soils: GJ1 — Eemian and early Vistulian; GJ2 — Lublin interglacial; GJ3a — Zbójno interglacial; GJ3b — Mazowian interglacial; GJ4 — Ferdynandów interglacial. Symbols of interglacial soils in profiles of Volhynian loesses: H — Horochów soil complex; K — Korszów soil complex; L — Luck soil; S — Sokal soil

Foothills. In the last years the progress in studies of loesses and glacial deposits has been considerable thanks to borings. The records on this matter for middle and north-east Poland were summed up by A. Makowska et al. (1972, 1976). They distinguished among other things loesses of alluvial facies up to 11.5 m in thickness, occurring under till underlaying sediments of the Ferdynandów interglacial (= Voigtstedt according to K.D.Erd 1978). They are thus loesses from the older glaciation of two south-Polish glaciations, distinguished at present as Nida glaciation (M. Harasimiuk et al. 1988). Loess in the profiles at Mąchocice on the river Lubrzanka, Czernica 2, Wydmacz and Kiełczyna were distinguished in

a similar stratigraphic situation (L. Lindner 1988, L. Lindner et al. 1987).

On the geological mapping commissioned by the State Geological Institute in Warsaw in 1989, several borings supervised among others by the author were performed on Grzęda Horodelska. In six boring holes in the Grzęda Horodelska interfluve, tills of various thickness from 1.5 to 7.0 m were encountered below LS or LN1. They occur only in one stratum and at a similar absolute height their area descends in the direction of fossil valleys. Therefore it seems to be the same till which is exposed at Kol. Zadębce and was found in the boring hole Zadębce II. This till was included into Sanian glaciation (= Elsterian II).

The oldest undertill loesses were bored through in holes: K—6 Czartowiec (L. Dolecki, J. Nowak 1990), K—5 Moniatycze, K—4 Stefankowice RSP, K—3 Stefankowice and in K—2 Kolonia Hrebenne. The oldest loesses strongly weathered were also found to occur in several borings in the northern foreland of Grzęda Horodelska, where in places they are exposed on the surface.

Taking into consideration the granular differentation and physicochemical features, as well as the distribution and sequence of layers of the oldest loesses on Grzęda Horodelska, four series of differentiated facies of different age were distinguished among them (Table 2, Fig. 4).

Series A,B,C were undoubtedly accumulated in the phase of the Sanian glaciation because they are covered with till; they were denoted by the symbol LN2, as it was done by H. Maruszczak in relation to the loesses on which Sokal soil has been formed (H. Maruszczak 1990 p. A–20).

Series D represents an older one from two south-Polish glaciations, i.e. Nida glaciation (= Elsterian I). In the upper part of this series at Stefankowice RSP, well-developed multilayer forest soil is found, which can be parallelled to Ferdynandów interglacial distinguished in the latest stratigraphic schemes (J. Rzechowski 1986, L. Lindner 1988). The particular series of sediments have been divided into subseries in relation to the character of the facies they represent (Table 2, Fig. 4).

THE OLDEST LOESS FROM SANIAN GLACIATION (LN2)

This period is represented by A,B,C series distinguished on the basis of lithological features. Granulometric studies were carried out by the areometric method of Casagrande in Prószyński's modification; sand fractions

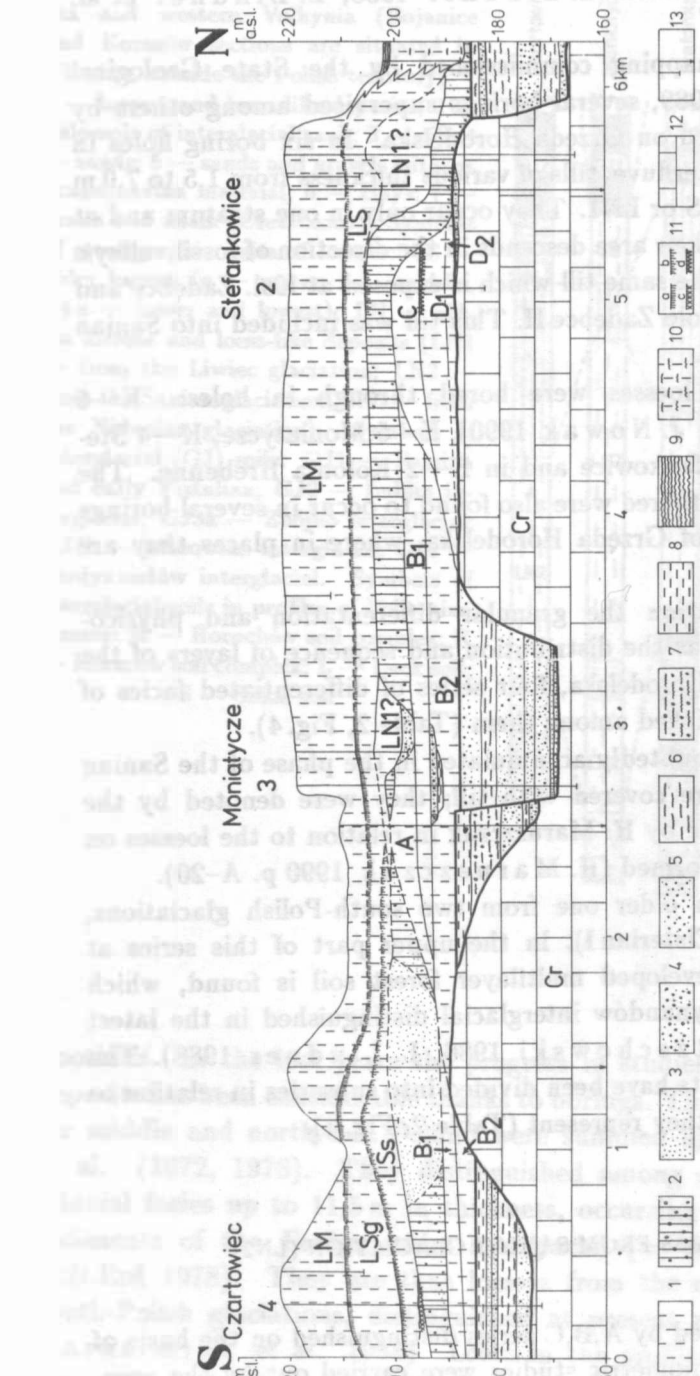

Fig. 4. Geological cross section of the Grzęda Horodelska

1 — loesses and loess-like deposits; 2 — till; 3 — sands; 4 — sands with gravels of Scandinavian rocks; 5 — sands with gravels of Cretaceous rocks; 6 — muds; 7 — muds with gravels of local rocks; 8 — clays; 9 — alluvial deposits; 10 — alluvial soils; 11 — interglacial soils: a) Eemian, b) Lublinian, c) Zbójno, d) Ferdynandów; 12 — upper Cretaceous rocks; 13 — borings. Other letter symbols — see text

were determined by sieve analysis from which the granulometric indices were calculated after Folk and Ward (Table 1). Carbonates were determined by Scheibler's method, humus by Tyurin's method, and iron oxides colorimetrically. The results of analyses are presented in Table 2.

In series A, bored only at Moniatycze in a high hypsometric site, small amounts of $CaCO_3$ occur, largely in the lower part in the form of fissural incrustation. It is darkgrey loess with a greenish tint, strongly compact, gleyed in the upper part and laminated in the lower part. In contrast to other series it is characterized by a maximal content of typical loess fraction and a small amount of colloidal fraction as well as by the lack of sand interbeddings. Series A apparently represents eolian facies accumulated within a higher relief form, which is proved by the present situation of the section.

Series B, with slope (B_1) and alluvial (B_2) facies, was bored at Moniatycze and Czartowiec. The area of the deposits of this series distinctly decreases southwards in the direction of the fossil valley of the pre-Huczwa river. The slope facies of loess (B_1) at Moniatycze is yellowish-greyish, stratified — streaked with grey and rusty laminae and lenses of silty sand; the sediment is sorted badly, which characterizes slope deposits. At Czartowiec it is a yellowish-brownish deposit in the upper part of the subseries, lower — grey-yellowish, streaky with light spots of $CaCO_3$ agglomerations. In the upper part these are traces of pedogenetic processes, in the form of a brownish horizon with strongly obliterated primary structure and agglomerations of rusty spots of iron and manganese compounds. The content of Fe_2O_3 in the lower part of this soil horizon is 2%, and 1.64% higher up.

The alluvial facies (subseries B_2) underlays the slope one (B_1). It is characterized by a more distinct lamination in the horizontal system, numerous lenses and interbeddings of silty sand. At Moniatycze river sand and limnic clays were bored on the borderline of subseries B_1 and B_2. Shells of the molluscs: *Pupilla loessica* Ložek, *Columella columella* Mart. were found in the sands, which Prof. S. W. Alexandrowicz determined as "loess" species. These shells must have been alluviated into the reservoir from the direct surroundings. The mechanical composition of alluvial deposits of subseries B_2 at Moniatycze is of silt and sandy silt; they are grey-brown, grey and lightgrey, sometimes with a strongly obliterated structure of streaking and with laminae of fine sand in the lower part. At Czartowiec the alluvial facies contains a little more clay, it is grey-white and yellowish, laminated by grey silt and lenses of silty sand.

Series C was bored only at Stefankowice RSP (boring hole No 2 in Fig. 1),

Table 2. Selected physico-mechanical and chemical features of oldest loesses LN2 from San glaciation and of loess-like deposits LN3 from Nida glaciation (mean indices for the layers studied)

Deposits studied and profiles	Thickness m	Md	Mz	σ_I	Sk_I	K_G	Content in %%					
							$CaCO_3$	Humus	Fe_2O_3	Loess fraction 0.05–0.02 mm	Sand >0.1 mm	Clay <0.002 mm
LN2												
Series A												
Eolian facies												
Moniatycze	4.00	5.00	5.43	2.91	0.59	2.87	1.05	0.02		59.50	2.50	9.50
Series B												
Deluvial facies B_1												
Moniatycze	3.50	5.38	6.04	3.31	0.47	1.35	5.15	0.04		35.00	5.00	18.50
Czartowiec	3.30	5.68	6.72	3.55	0.52	1.62	13.40	0.07	1.82	38.80	0.41	20.0
Alluvial facies B_2												
Moniatycze	3.00	5.15	5.78	2.73	0.40	2.36	6.17	0.12		46.30	9.80	13.42
Czartowiec	1.80	4.60	6.07	3.72	0.66	1.27	18.28	0.04	1.29	18.25	24.30	21.50
Series C												
Eolian facies												
Stefankowice	5.30	6.05	7.20	2.78	0.61	1.22	3.19	0.11	1.92	41.40	0.40	22.70
LN3												
Series D												
Eolian facies D_1												
Stefankowice	4.20	7.15	7.78	2.85	0.42	0.90	0.00	0.08	1.37	33.40	0.92	31.00
Eolian facies D_2												
Stefankowice	2.60	6.48	7.17	2.94	0.34	0.92	26.90	0.12		34.70	5.04	27.10
Hrubieszów CPN	8.00	7.37	7.61	2.80	0.22	0.65	24.41			21.20	0.08	29.20
Teratyn	1.80	7.26	6.98	1.93	-0.11	0.95	29.30	0.36		23.50	10.50	16.50
Alluvial facies D_3												
Kol.Hrebenne	2.90	5.73	5.87	2.49	0.13	1.38	6.31			22.65	12.70	11.00

under the till of the Sanian glaciation. It covers strongly weathered loess-like deposits (undoubtedly from Nida glaciation) subjected to pedogenesis in the upper part in the period of the Ferdynandów interglacial (?). It has the features of the eolian facies of loess, which is accounted for by the granulometric indices and the frequency curves plotted for samples of this loess. Series C contains on average 41.4% of typical loess fraction; it is weak-carbonate, and carbonate-free in the upper part, lightgreenish-yellow in colour, in places with fine carbonate concretions. Attention is attracted by the content of colloidal fraction up to 19-27% (Table 2). The deposits of series C have been preserved at a high hypsometric position like the deposits of series A at Moniatycze.

THE OLDEST LOESS FROM NIDA GLACIATION (LN3)

Among the loess-like deposits representing this unit, i.e. in series D_1 a weathered eolian facies (subseries D_1), an eolian carbonate facies (subseries D_2) and an alluvial one (D_3) have been distinguished.

Subseries D_1 is totally strongly weathered and changed by pedogenesis. In the upper part there occurs a soil distinctly separated into genetic horizons: A_1–A_1Bg–Bg–Cg. The accumulation horizon 30 cm in thickness, disturbed by solifluction, contains 0.35% of humus. A gleyed browning horizon with a content of iron oxides increasing down the profille is well distinguished. In the lower part of the soil disturbance traces of undefinite genesis can be found. The lowest part of subseries D_1 is constituted by lightgrey silts with colour streaks of Fe_2O_3 and carbonate traces. The thickness of subseries D_1 is 4.4 m.

Subseries D_2 has features of eolian facies, the evidence of which are granulometric indices and an analysis of the frequency curves plotted for these sediments. It is characterized by a considerable content of carbonates. At Stefankowice its thickness is 2.6 m and it lies on coarse sands with gravels of the local upper-Cretaceous rocks, lidites and quartz, covering the substrate with a thin layer (Fig. 4). In the upper part of the subseries there occur denudation products of unknown paleosol. These are silty loams with a considerable admixture of clay, dark-grey and humus with lenses of rusty loam containing up to 50% colloidal fraction. Below the soil deluvia the deposit is strongly carbonate (17.3–31.7%); the content of colloidal fraction is similar to that in the overlying subseries D_1. Sediments similar to subseries D_2 were bored at the petrol station in Hrubieszów within the fossil valley of the pre-Huczwa river. They occur there under glaciolacustrine clays.

Table 3. Stratigraphic scheme of the oldest loesses on the Grzęda Horodelska

Loesses	Fossil soils	Occurence in profile	Stratigraphy of Quarternary deposits of SE Poland (according to M. Harasimiuk et al. 1988, H. Maruszczak 1990, and L. Lindner 1988)
	GJ3a/LN1 (Luck horizon)	Nieledew Czartowiec	Krępiec (= Zbójno) Interglacial
LN1		Nieledew Kol.Zadębce Zadębce II Czartowiec	Liwiec glaciation
	GJ3b on till (Sokal horizon)	Kol.Zadębce Zadębce II	Mazovian Interglacial
LN2 (series: A,B,C)		Moniatycze Czartowiec Stefankowice Zadębce II Kol.Zadębce	Sanian glaciation
	GJ4/LN3	Stefankowice	Ferdynandów (=Malopolanian) Interglacial
LN3 (series D)		Stefankowice Hrubieszów CPN Teratyn Kol.Hrebenne	Nida glaciation

Sediments similar to subseries D_2 were also found in the high hypsometric position, on the slope of interfluve under a thin cover of older loess at Teratyn (Fig. 1).

The alluvial facies (subseries D_3) has been little known. It occurs at Kol. Hrebenne under the till of the Sanian glaciation, in low hypsometric position in the neighbourhood of the Bug river valley. Below subseries D_3 there occur sands with gravels apparently of the Eopleistocene age, covering the upper-Cretaceous rocks. They are grey and dark-grey clayey loams with lenses of organic substance in the upper part. They contain on average 12.7% of sand fraction, the amount of which increases in the lower part of the layer. The carbonates content is lower than in the overlying till, and higher than in the underlying sands with gravels (Table 2).

The results of the studies make it possible to parallel the distinguished oldest loesses and the fossil soils interbedding them with their corresponding

stratigraphic units in the schemes elaborated for the Quaternary sediments of Poland, particularly its SE part (Table 3).

CONCLUSION

1. Till from Sanian glaciation (= Elsterian II) occurring among the oldest loesses, dated by the TL method for 445 and 478 ka, constitutes on Grzęda Horodelska a significant reper for stratigraphic parallelization of middle Pleistocene periglacial and glacial deposits. The occurrence of this till only in one stratum and lack of older glacial sediments indicate that the area studied was beyond the extent of the Nida inland ice (= Elsterian I).

2. On the till of Sanian glaciation there can occur paleosols from the Mazovian interglacial (GJ3b), Zbójno (GJ3a), Lublin one (GJ2) and Eemian (GJ1). The finding of the interglacial soil rank in the particular profiles does not thus determine unambigously the higher lying loess stratum to be classified into a definite stratigraphic unit.

3. Over Sanian till and the soil GJ3b from Mazovian interglacial developed on it, the oldest loess LN1 from Liwiec (= Fuhne) glaciation occurs at Kol. Zadębce. However, below this till the oldest loess LN2 from Sanian glaciation is found. Moreover the oldest loess LN3 from Nida glaciation is found below LN2 in the profile at Stefankowice RSP. Between LN2 and LN3 a soil of interglacial rank has been distinguished which can be parallelled with Ferdynandów interglacial (= Voigtstedt). This soil is developed on LN3 layers.

4. Layers LN2 and LN3 of loesses occur in facies: eolian, deluvial and alluvial. These facies have been distinguished on the basis of the results of granulometric, physico-chemical as well as geomorphological analyses. It appears from them that the environmental conditions of accumulation of LN2 and LN3 were similar to those in the accumulation period of older (LS) and younger (LM) loesses.

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STRESZCZENIE

Na Grzędzie Horodelskiej stwierdzono występowanie — poniżej lessów młodszych (LM) vistuliańskich oraz starszych (LS) saaliańskich — lessów i utworów lessopodobnych najstarszych (LN) ze zlodowaceń: Liwca, Sanu i Nidy. W nawiązaniu do propozycji H. Maruszczaka (1990) oznaczono je kolejno symbolami: LN1, LN2, LN3. Warstwy LN1 ze zlodowacenia Liwca akumulowane były na morenie zlodowacenia Sanu, objętej w górnej części pedogenezą rangi interglacjalnej. Gleba kopalna integlacjalna rozwinięta jest także w górnej części LN1. Te dwie gleby rozwijały się w okresach wyraźnych ociepleń w interglacjale wielkim = mazowieckim (= Holstein), rozdzielonych ochłodzeniem wyodrębnianym ostatnio jako zlodowacenie Liwca (L. Lindner 1988). Na Wołyniu znaleziono identyczną sekwencję gleb interglacjalnych i lessów; górną glebę wyodrębnia się tam jako poziom łucki, dolną — rozwiniętą na morenie zlodowacenia Oki (= San = Elsterian II) — jako poziom sokalski (A. Bogucki 1987).

Poniżej moreny zlodowacenia Sanu nawiercono lessy z fazy wstępującej tego zlodowacenia (LN2). Jeszcze niżej występują lessy i utwory lessopodobne (LN3) ze zlodowacenia Nidy (= Elsterian I), w górnej części przekształcone przez pedogenezę interglacjalną. Ta najstarsza ze stwierdzonych gleba rozwijała się zapewne w interglacjale ferdynandowskim (= Voigtstedt wg K. D. Erd'a 1978).